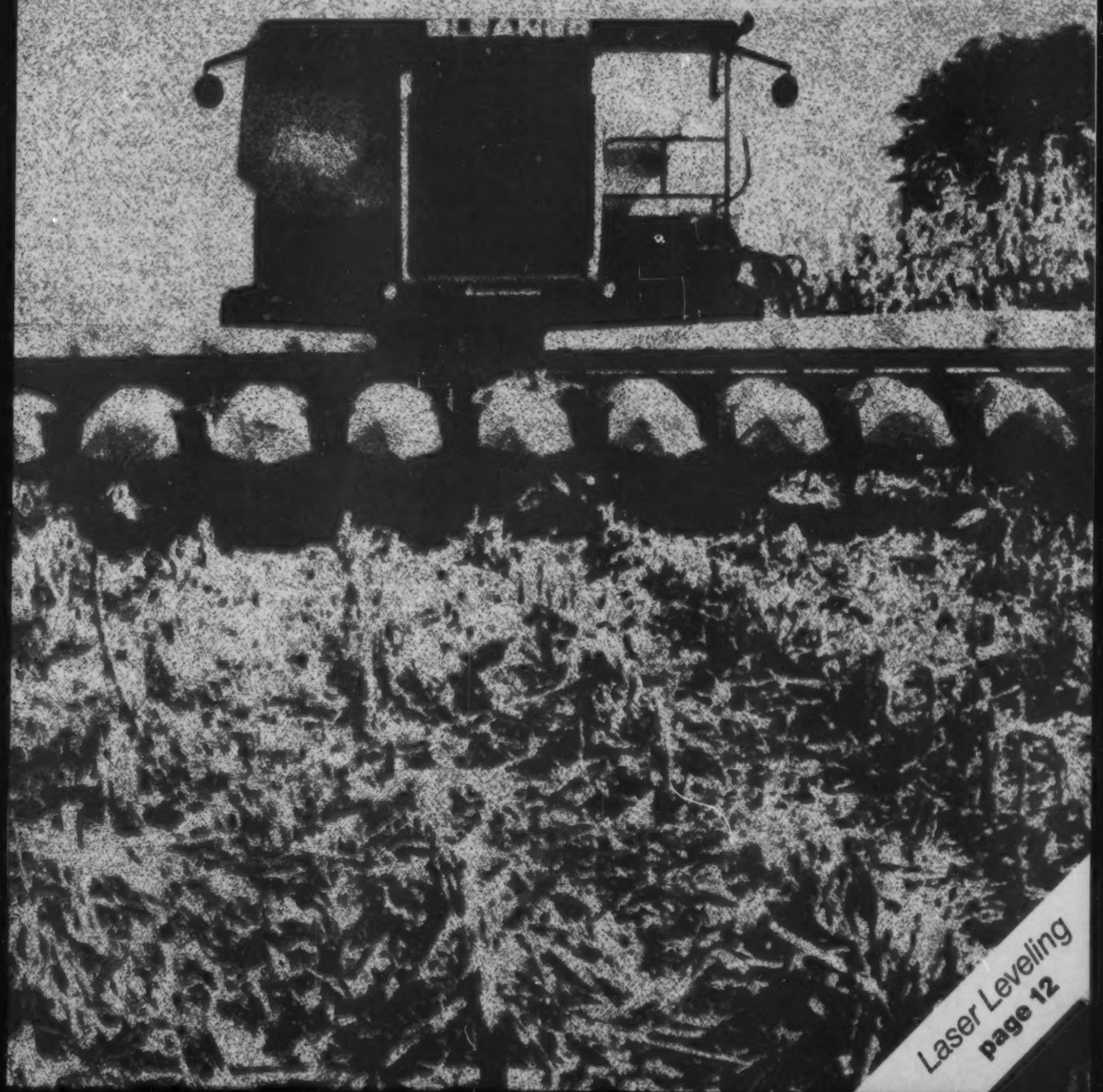
FARMLINE

United States Department of Agriculture

Economic Research Service

Volume III
Number 7
August 1982

E.T. Emerging Technologies



Laser Leveling page 12

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FARMLINE is published 11 times a year by USDA's Economic Research Service. Subscription price is $16 a year to U.S. addresses ($20 foreign). Order from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Ask for *FARMLINE* and make your check payable to Superintendent of Documents.

Address single copy requests and editorial correspondence to *FARMLINE*, Room 400 GHI Bldg., USDA, Washington, D.C. 20250.

The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this publication has been approved by the Director of the Office of Management and Budget through March 31, 1987.

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PERSPECTIVES

Recently compiled farm income statistics for 1981 clearly illustrate the cost-price squeeze farmers have experienced since 1980. Cash receipts from farm marketings rose only 3% last year, while cash production costs rose nearly 9%. The result: Net cash income declined 12% from 1980 and 15% below the 1979 peak. Current large crop supplies, high interest rates, and sluggish consumer demand suggest another year of declining cash farm income.

Red meat and poultry output dropped 3% below year-earlier levels in the first half of this year, contributing to a sharp upswing in cattle and hog prices. Combined with lower feed costs, the improved prices provided livestock producers with the most profitable situation since mid-79. Price gains will encourage some expansion in feeding, but no sharp turnaround is likely unless the economy perks up.

Texas storms sharply cut U.S. cotton harvest prospects. U.S. production is now forecast at about 10 million bales, down from 15.6 million last season and the smallest crop since 1975. Analysts still expect large grain and oilseed crops, however. With the record winter wheat crop, the total 1982 wheat harvest may be our second largest ever. The soybean crop is also expected to be the second largest, and the corn crop the third largest.

With large crops, storage will be tight this fall, says ERS economist T.Q. Hutchinson. He estimates that about 14.5 billion bushels of unused storage capacity will be available on October 1. That's more than a billion above what's needed to store prospective grain and oilseed harvests, but the space isn't always where the crops are. Nearly all on-farm storage is likely to be filled during harvest, and at least 1.8 billion bushels of grain will need transportation to commercial facilities, which will also be strained. Many short-duration, local shortages may occur until stocks are drawn down, but all sorts of short-term storage can be improvised, if need be.

The USSR will again be a dominant factor in grain trade. Estimated acreage seeded to the 1982 crop is the lowest since 1972, and weather has withered yields. As a result, the Soviets are likely to harvest their fourth consecutive poor crop this year, and they're expected to maximize imports to maintain livestock herds. Based on preliminary trade totals for July 1981-June 1982, the U.S. regained its position as the largest grain supplier to the USSR, though we provided only a third of their imports versus half to three-fourths in the years before the embargo.

FARMLINE

Volume III
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FEATURES

_E.T._: Emerging Technologies *by Robert McElroy* 4

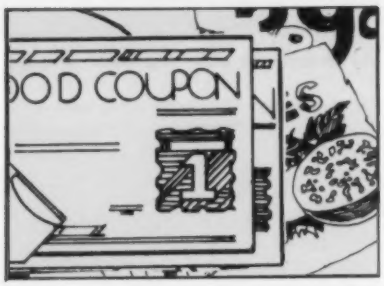
Technological innovation helped make U.S. farms the most efficient in the world, and we haven't reached our limits. Breakthroughs in food and fiber production may play an even greater role in the decades ahead. A new generation of bigger, more specialized farm machinery is already moving into fields, while biologists are beginning to harvest the first fruits of genetic engineering.

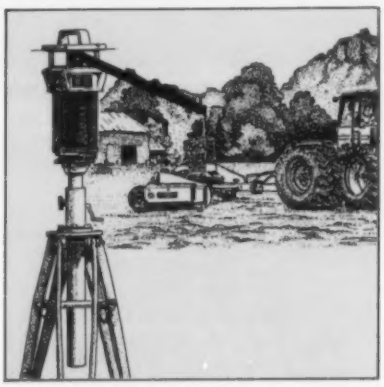
Couponing: Ticket to Higher Food Sales *by Daniel R. Williamson* 8

To shoppers, coupons offer a chance to snip nickels and dimes off prices. But, to the U.S. food industry, coupon advertising is a billion dollar a year effort to capture customers. Ninety billion were issued in 1980, and redemptions had a total value of about $1 billion. Even so, for the issuers, the costs of coupon advertising are more than offset by increased sales volume.

Laser Leveling and Farm Profits *by Harry Ayer* 12

The costs of laser leveling a field can be large, but so can the potential benefits. Laser leveling can save water and improve profits on many gravity-irrigated fields in dry western states, according to economist Harry Ayer. Ayer looks at the costs and benefits of laser leveling, and considers some of the conditions under which lasering might be profitable for the individual producer.





DEPARTMENTS

Perspectives: Late-Breaking Agricultural News and Analysis 2

Agricultural Roundup: Billion-Dollar Markets; Newsline Schedule 10

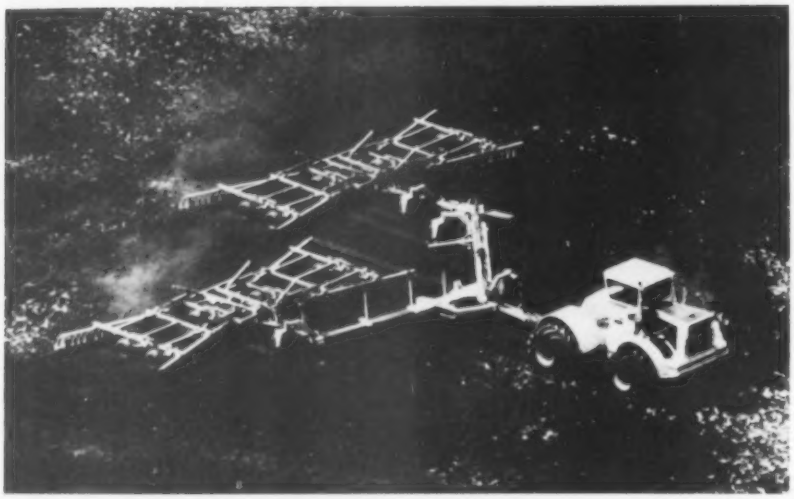
Farmline Trends: Monthly Price Monitor 15

The following USDA reports cited in this issue can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Ask for reports by title and number, and make checks payable to Superintendent of Documents.

New Technologies To Raise Agricultural Efficiencies, **AIB–453. Price: $4.50.**

Couponing's Growth in Food Marketing, **AER–486. Price: $3.25.**

E.T. Emerging Technologies



An 80-foot disk with "Big Hitch" and 525 horsepower tractor.

A 24-row planter; does six times the work of planters a decade ago.

No-till grain drill; cuts fuel use and helps control erosion.

Technological advances, which have made U.S. farms the most efficient in the world during the past half century, may play an even greater role in the next two or three decades.

A new generation of bigger and more specialized machines is already moving into fields, enabling farm operators to increase their harvests with more efficient cultivation and less labor.

In addition, biologists are now beginning to harvest the first fruits of a new field of genetic engineering which, experts say, offers great potential for breakthroughs in food and fiber production.

Although genetic engineering is so new that it's impossible to gauge its ultimate impact (how can you measure the benefits of a heretofore nonexistent crop?), some evolving farm machinery has already shown impressive advantages in reducing the inputs and expenses of farming.

Here are some major technological developments which are still on—or just off—the drawing board:

Tractors

Big tractors of 300-plus horsepower are becoming common on farms today. Last year, a 650 hp model was marketed, and a prototype 747 hp model was built. These powerful new machines may be needed to pull the huge, heavy rigs that are being developed for tillage and planting.

A 120-foot disk, already available, is ideally suited for these big machines. With a special hitch to accommodate heavy, complex rigs, these tractors can pull larger chisel plows, field cultivators, drills, and other big equipment.

Efficiencies with these new machines have already been documented. One farmer used a 525 hp tractor to replace five older tractors and tillage machines, while using only half as much fuel to work his fields. Five tractor operator jobs were eliminated, and the mechanic who serviced the five older units be-

came the operator-mechanic of the new system.

The 650 hp machines have been sold mostly to large wheat growers in areas of the Southern Plains and Pacific Northwest. But they may have even greater potential use on the very large, unbroken fields of Canada, Australia, Argentina, Brazil, and South Africa. If so, such machinery could affect U.S. food and feed grain exports, giving our competitors a new edge by lowering their per-unit costs of production.

The large tractors may also be suited for no-till corn and soybean production. The 350 hp versions of the super-horsepower tractors are already being adopted by midwestern corn and soybean producers who are also using heavier attachments.

Tillage isn't the only advantage of the big machines. Using special plows with lasers to guide them, the machines can install about one mile of continuous-roll plastic drainage tile per hour. This is many times the capacity of open ditch machines where clay or concrete tiles are hand set.

However, operators may be hesitant to adopt this method because they're not sure how long plastic tile will last, and because they can't easily measure or inspect tile that is plowed in. When tile is laid by open ditch methods, the turned-over soil gives a different color that enables a farmer to find exactly where the tile lies.

Planters

A 24-row grain planter for row crops, which is about six times as large as most available a decade ago, is now on the market. Attached to at least a 160 hp tractor, the new planter can be equipped with liquid or dry chemical and fertilizer attachments to efficiently work large fields.

The planter can be used with a moldboard plow and associated field preparation equipment, or it may be adapted to minimum tillage soil preparation methods.

Applying chemicals on hilly farmland.

A recently developed no-till drill can apply as much as 2,000 pounds of packer wheel pressure per seed-opener, while simultaneously banding phosphates and nitrogen around the seed and applying herbicides. The packer wheel packs soil firmly around the seed, removing air pockets. The drill can also apply liquid, gas, or dry fertilizers.

The largest model of the new drill is 20 feet wide, weighs 33,000 pounds, and can carry a 25,000-pound payload. The manufacturer claims that fuel use for tillage and planting is cut from 6½ gallons per acre under conventional tillage methods to 1½ gallons per acre. The savings come from reducing the number of trips through the field. At least a 270 hp tractor is needed to pull this model.

Such no-till planter-cultivator systems are drawing more and more research because they may better control soil erosion and conserve available moisture than conventional methods which turn over the soil and require many more tractor runs through the fields. Fuel consumption is also reduced.

Sprayers

Developments are underway in several areas to improve chemical application to crops. As noted, some planters and field preparation machines now apply chemicals simultaneously with other fieldwork.

Special application equipment is newly available to increase efficiency by such techniques as "knifing in" chemicals—cutting a slit and concentrating application in a narrow band below the surface in one run through the fields. Conventional methods waste substantial amounts by broadcasting chemicals, then tilling them into the soil with two or three trips.

To minimize soil compaction from the heavy new equipment, many sprayers are now equipped with large, flotation tires.

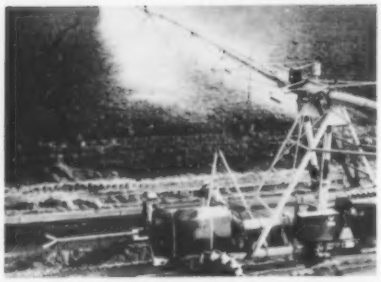
The new equipment can replace moldboard plows, which were previously needed to place phosphate and potassium fertilizers at the proper depth. This makes the new sprayers attractive for no-till practices.

Aerial spraying is also being improved with the use of small helicopters which can precisely service small or sloped fields that aren't suited to fixed wing aircraft. The helicopter is much more precise in applying chemicals because it can vary its speed and altitude more easily, and because of the downward draft from its blades.

Irrigation Systems

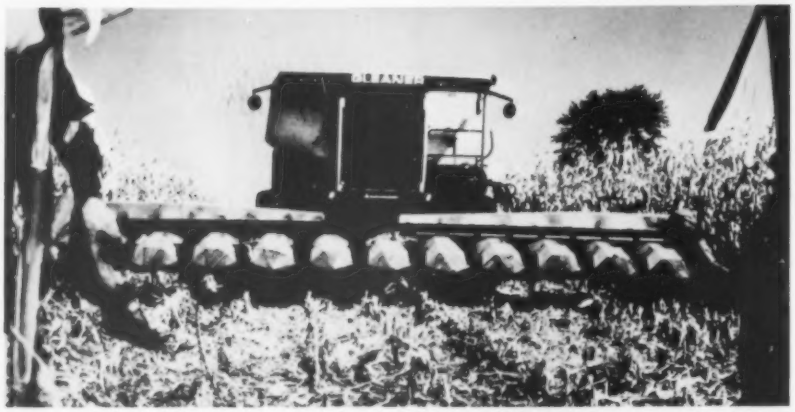
Several new irrigation techniques offer improved efficiency. New lateral-move irrigation systems can travel across a field using a single pump to draw water. This system covers rectangular plots far better than center pivot systems, which may need several pumps to cover the same area—and more energy to run them.

Water is provided by an open ditch or a series of pipes at one end or in the middle of the area. This system can irrigate



A linear (lateral move) irrigation system; uses a single pump.

A "knife-in" applicator with large, flotation tires.



Featured on the cover: one of the latest, super-large combines with 12-row corn head that can harvest 2,000 bushels or more per hour.

Four-row cotton picker, with older two-row pickers in background.

a field 2 miles by 1 mile or larger. Crop chemicals and fertilizers can also be applied through the system.

Computer control can make irrigation systems use water with maximum efficiency. An experimental computer-controlled lateral-move system is equipped with lasers to keep it perfectly aligned as it moves. Researchers plan to use solar panels to power the unit, making it self-contained and self-powered.

The experimental system's computer program will include soil and weather information that takes into account solar radiation, air temperature and humidity, wind speeds, soil moisture and evaporation, and plant transpiration. As soil and water sensors indicate the need for water, the computer will turn on the system until the crop's water needs are satisfied.

The importance of heightened efficiency in irrigation has been underscored by declining water supplies, tighter water use laws, and high energy costs.

Harvesters

Technological improvements will also help farmers harvest at lower costs and with less waste. New, very large combines with up to 12-row corn heads can harvest 2,000 bushels or more per hour—a quarter section field of corn per day. This is five times greater capacity than existed a decade ago.

Similar gains have been made in equipment for soybean and wheat harvesting. Where soybean fields aren't level enough for harvesting with flat sickle heads, floating heads have been developed. In the past, when small machines were used for harvest, terrain wasn't so much an obstacle. For small grains, leveling devices enable efficient combine use in hill country.

To effectively use such large combines, the farmer must plant row crops with large, complementary equipment so that row alignment efficiently matches the spacing of the combine head.

Operating such combines with maximum efficiency may require a small fleet of trucks and wagons, in addition to large handling, drying, and storage facilities.

While many such innovations came from engineers' schemes, others were hatched by tinkering farmers. A new, 40-foot combine grain head was born when a farmer put three combine headers together into one folding 40-foot unit and mounted it on an existing combine. Several manufacturers are interested in the design, since new machines have the internal capacity to handle the extra grain.

Similarly, a 40-foot swather was fashioned to cut and windrow hay by combining two 20-foot, pull-type swathers into one. The result of both of these harvester innovations is that the farm needs fewer tractors and combines.

Recently, a 4-row cotton harvester was introduced to allow one operator to glean about double the cotton acreage harvested by smaller machines.

The machine, which reduces harvesting costs by about one-sixth by reducing labor and fuel inputs, can be equipped with a basket extension that holds up to 5,800 pounds of raw cotton—nearly 50 percent more than any 2-row picker.

It harvests over 3¾ acres or 7½ bales per hour and dumps the cotton in large, compressed stacks which can be left in the field until a truck picks them up. Previously, trucks had to trail harvesters to receive the loose cotton. The new harvester frees equipment and reduces costs for drivers' wages and fuel.

Biological Technologies

Although far less visible than mechanical innovations, biological technologies may have far greater potential for improving inputs, agricultural output, and food processing to meet rising world food demand.

Recent advancements in genetics, particularly genetic engineering, offer hope of producing several breakthroughs:

- New chemical compounds to prevent plant and animal diseases. Development of a new generation of antibiotics for treatment and prevention of animal disease is very close to completion. Recently, genetic engineering produced a vaccine for one strain of hoof-and-mouth disease.

- Stimulants to promote plant and animal growth, and to reduce use of scarce inputs. Researchers are trying to develop hormone-like growth regulators that could increase crop yields at least 10 to 15 percent.

- New plant and animal strains with identical and preferred physical and nutritional characteristics. Such new species could be developed that survive more easily in hostile environments not currently suited for crop production, such as salty or arid soils.

- Less expensive methods of producing agricultural inputs. For example, new corn varieties could be developed to take nitrogen directly from the atmosphere.

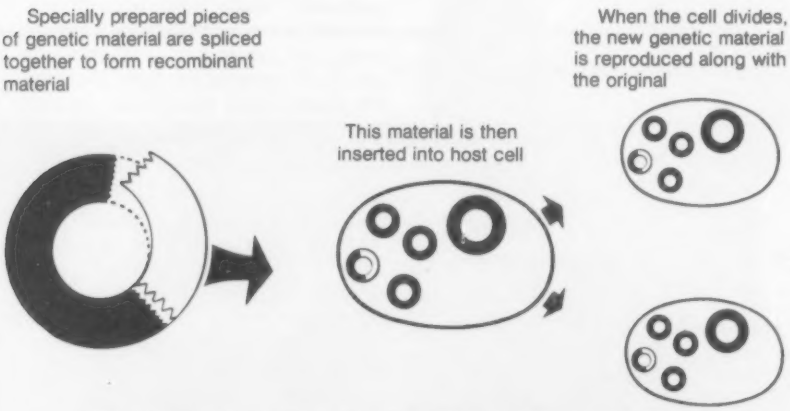
- Nontraditional foods and safer food additives. New additives are being developed to preserve human food and animal feed longer, and to make it more palatable and nutritious.

While no one can assess the impact of these and other technological advances on agriculture until they're actually in use, it takes little imagination to see the potential.

One thing is certain: the world's capacity to produce more and better food hasn't met its limits. □

[*Written by economist Robert McElroy of the National Economics Division of USDA's Economic Research Service. Further information can be found in the report,* ***New Technologies to Raise Agricultural Efficiencies,*** *by McElroy and Kenneth R. Krause.*]

Gene Splicing: How it Works


Specially prepared pieces of genetic material are spliced together to form recombinant material
This material is then inserted into host cell
When the cell divides, the new genetic material is reproduced along with the original

This simplified drawing shows how genetic material from one cell is spliced into similar material from another. The recombined material is then inserted into a host cell. When this cell divides, the new cells that result each carry the recombinant material. And future cell divisions also carry the new material.

Couponing: Ticket to Higher Food Sales

To shoppers, coupons offer a chance to snip nickels and dimes off prices. But, to the U.S. food industry, coupon advertising is a billion dollar a year effort to capture customers.

Ninety billion food advertising coupons were issued in 1980. One out of 20 of those were redeemed at a total value of about $1 billion, according to a study by economist Anthony E. Gallo of USDA's Economic Research Service.

"About 3.3 cents of every $10 spent by the consumer goes to cover the gross cost of coupons," Gallo explains. "However, there is no hard evidence that food prices would drop in the absence of coupons, because manufacturers would shift to other types of advertising."

While consumers can save money, food manufacturers find that coupon costs—average face value of 23.5 cents according to an ERS survey, plus 8.5 cents in handling expenses in 1980—are more than offset by increased sales volume. Coupons help boost sales by:

- Lowering the retail cost for the item, after the coupon value is subtracted from the price. This undercuts competition.
- Increasing consumer awareness of the product.
- Improving shelf space and position in stores.

The effectiveness of coupons appears to be drawing more attention in the food industry. The number of coupons issued jumped from 10 billion in 1965 to 90 billion in 1980.

The greatest growth occurred from 1974 to 1980 when the number of coupons issued increased an average of 20 percent a year. During the 1970's, coupons' share of total food advertising and promotion costs jumped from 6 percent to 11 percent.

"This impressive growth, however, needs to be viewed within the total food promotion picture," Gallo cautions. "Coupons still comprise the smallest portion of the four major types of food advertising and promotion."

Television and radio accounted for 41 percent of food advertising expenditures in 1979, newspapers and magazines took 24 percent, consumer premiums such as trading stamps accounted for 24 percent, and coupons took 11 percent.

Redemption Rates

Dollar outlays for coupons would be far higher if redemption rates kept pace with the increase in numbers issued. However, while total distribution tripled from 1974 to 1979, redemptions only doubled. In 1974, 1 in 16 food coupons were redeemed, compared with 1 in 20 in 1980.

Not all coupons redeemed at food stores are for food products. In fact, a recent survey of one grocery chain found that only 3 out of 5 coupons redeemed were for food. Such nonfood items as household supplies, pet food, tobacco, and general merchandise accounted for 39 percent of coupons redeemed.

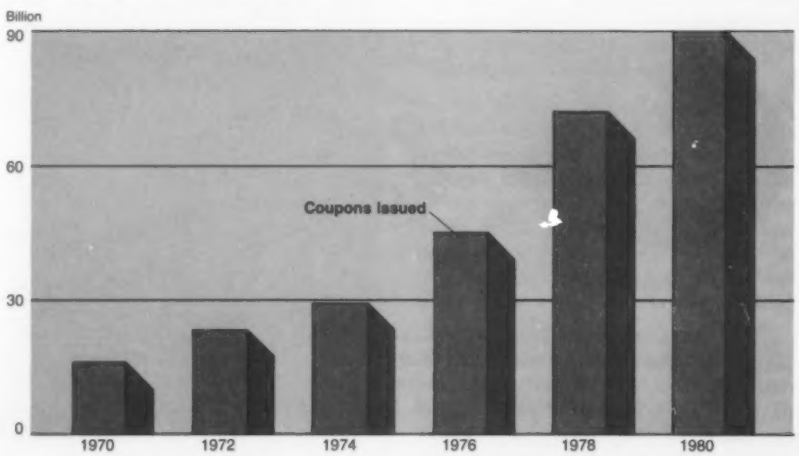
Nationally, nonfood items comprise only about 15 percent of the chain's sales value, so couponing appears disproportionately high for these products.

Among food items, coffee and highly processed products such as breakfast cereals, cake mixes, and prepared foods were the most common among redeemed coupons. They accounted for 60 percent of the total food coupon value, even though they represent only 10 percent of all food expenditures.

Not surprisingly, highly processed—highly couponed—foods also tend to be the most highly advertised in broadcast and print media. Thus, couponing is often part of a broader advertising strategy to promote a given product.

One important tool of product promotion is shelf placement. Retailers normally provide more and better shelf space to the more popular brands. This, in turn, encourages still more sales—at the expense of competitors.

Coupon Distribution Swells in the 1970's



Coupons create consumer demand for a specific brand, pressuring the retailer for prime shelf space.

Couponing creates consumer demand for a specific brand, pressuring the retailer for prime shelf placement, explains USDA economist Larry G. Hamm, who co-authored the study with Gallo.

Shelf space struggles aren't the only problem that coupons present to retailers, Hamm says. Store-brand products, which are usually priced about 20 percent below national brands, lose their crucial competitive advantage unless the retailer trims prices during couponing campaigns by national brand rivals.

Retailers also promote coupons, but often with a different objective. While manufacturers issue coupons to sell a given product, retailers use them to lure customers into the store—as well as to promote store-brand products.

One common strategy used by retailers is double (or even triple) couponing. The store matches the coupon premium offered by the manufacturer, thus giving customers twice the discount. To do so, however, the retailer must absorb the loss or compensate by raising other prices.

In-ad coupons are another common form of retailer couponing. Coupons—often for store-brand products, produce, and fresh meats—are printed inside a store's newspaper ads. If national brands are thus promoted, the manufacturers usually reimburse at least some of the cost and may provide advertising formats.

Handling Costs

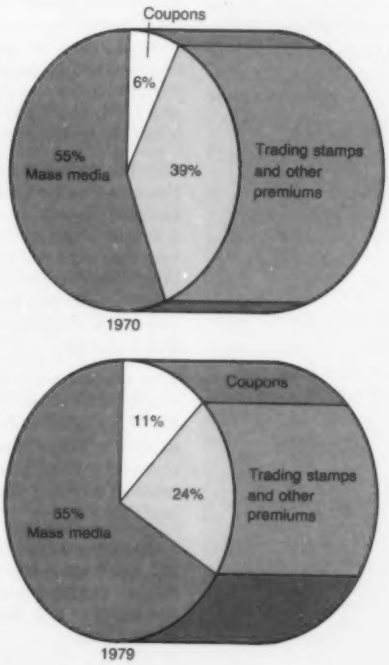
Surveys show actual handling costs of 5 to 9 cents per coupon redeemed, depending on the store. The average cost, Gallo estimates, is about 8.5 cents. About 25 percent of these costs cover the extra 5 seconds spent by the bagger and checker in accepting coupons. Other major costs are : coupon processing by the store, 45 percent; finance charges, 10 percent; and clearinghouse fees, 10 percent.

The clearinghouse acts as the manufacturer's agent in handling coupon reimbursements to retailers.

On the other end of the food coupon chain are consumers who, in the judgment of manufacturers and retailers that spend millions of dollars to issue coupons, buy much more of a brand with coupons than without. An ERS survey found that four out of five households use coupons.

Coupons Capture a Larger Share of the Food Advertising Dollar as Trading Stamps Decline

(Percent of food advertising expenditures)



Gallo says that money lies at the root of coupon clipping.

While the sharp rise in coupon distribution encouraged use, Gallo says sharply rising food prices from 1971 to 1979 were also a major factor. Many consumers were prodded to find ways to reduce food costs. Another incentive: the average face value of coupons rose two-thirds during that period.

If rising food prices constituted a major incentive for coupon use, Americans who have been squeezed most may derive the least benefit. Gallo says studies show that lower income consumers use coupons less frequently than do other income groups.

"There are two possible reasons," Gallo says. "Either they consume fewer products that offer coupons, or they have access to fewer coupons."

The evidence, he asserts, points more toward limited access to coupons.

"While data show that expenditures per person for leading couponed products are about the same for all income groups, lower income consumers spend significantly less for reading materials," Gallo says. "This limits access because 90 percent of coupons are distributed through newspapers and magazines."

Gallo also notes that companies specializing in direct mail coupons tailor lists to middle and upper income groups with large families who spend more.

But, do coupons really benefit users? Gallo says consumers who don't use coupons forgo the average face value of 23.5 cents while saving the coupon issuer 8.5 cents in handling costs.

However, the nonuser also saved the time required to clip, sort, and carry coupons to the stores—and many consumers find this too high a cost. □

[Based on the report ***Couponing's Growth in Food Marketing,*** *by ERS economists Anthony E. Gallo, Larry G. Hamm, and James A. Zellner.]*

AGRICULTURAL ROUNDUP

Billion Dollar Markets

Twelve nations share a title that fit only seven nations 4 years ago: All are billion-dollar customers for U.S. agricultural exports.

Together, these top 12 markets accounted for 62 percent of U.S. farm export earnings in fiscal 1981. Their purchases grew from $16.7 billion in 1978 to nearly $27 billion last year. Slightly more than half of this increase came from higher U.S. commodity prices, while the rest reflected larger export volume.

With the $10 billion boost in annual sales to these customers, total U.S. agricultural export receipts rose $16.5 billion to a record $43.8 billion from 1978 to 1981. Sales volume also grew substantially in this period—up more than 30 million metric tons, or 23 percent.

(Forecasters don't expect U.S. export earnings to set another record this year. Sales may drop to around $42 billion. Volume, however, is likely to reach a new high of 168 million tons.)

Japan, which in 1970 became the first nation to edge past the billion-dollar mark, remains our largest market by far. U.S. agricultural exports to Japan were valued at $6.7 billion last year, giving Japan the same 15.4-percent share of U.S. sales that it held in fiscal 1978. Feed grains, soybeans, and wheat are the best-selling products.

Spain, our ninth largest buyer, was the only nation besides Japan to retain its 1978 position. All the others changed rankings, but the most dramatic moves were those of Mexico, China, and the USSR.

The Billion-Dollar Markets of 1981 Account for about 62 Percent of Total U.S. Agricultural Export Earnings

	U.S. export value		Market ranking		Share of total	
	1978	1981	1978	1981	1978	1981
	$millions		*ranking*		*percent*	
Japan	4,203	6,737	1	1	15.4	15.4
Mexico	735	2,732	10	2	2.7	6.2
Netherlands	1,395	2,269	5	3	5.1	5.2
West Germany	1,797	2,242	3	4	6.6	5.1
China	370	2,184	19	5	1.4	5.0
Korea	1,059	2,137	7	6	3.9	4.9
Canada	1,575	2,090	4	7	5.8	4.8
USSR	1,868	1,708	2	8	6.8	3.9
Spain	912	1,389	9	9	3.3	3.2
Italy	964	1,230	8	10	3.5	2.8
Britain	1,118	1,154	6	11	4.1	2.6
Taiwan	729	1,105	11	12	2.7	2.5
Total,12 markets	16,725	26,977	—	—	61.3	61. 6
Total, all markets	27,289	43,788	—	—	100.0	100.0

All years are October–September fiscal years, and all figures are adjusted for transshipments through Canada, Belgium, the Netherlands, and West Germany.

Mexico jumped from the tenth ranked market to number two, accounting for a 6.2-percent share of U.S. export earnings. From fiscal 1978 to 1981, U.S. feed grain sales to Mexico rose from $242 million to more than $1 billion, sales of wheat and flour to Mexico went from $36 million to $227 million, and U.S. exports of vegetables, primarily dried beans, increased 20-fold to $296 million.

China, meanwhile, made its way from the 19th ranked market to the fifth leading market, taking more than $2 billion in U.S. farm products—5 percent of total U.S. export sales—last year. For the last 2 years, China has been the world's biggest buyer of U.S. wheat, which has made up more than three-fifths of the total value of China's agricultural purchases from the United States. Cotton has been the second leading import item.

Although six of the 12 nations dropped in ranking, only the USSR—number two in 1978—showed a decline in actual value of farm products purchased from the United States between 1978 and 1981. The export embargo is largely responsible.

With the exception of the Netherlands, the European markets and Canada accounted for a smaller share of U.S. sales than they did a few years earlier. In contrast, Mexico and Asian markets, with the exception of Taiwan, maintained or improved their rankings.

Who will be next to join the billion-dollar "club"? Egypt is a good candidate. U.S. agricultural exports to Egypt have been increasing rapidly, and sales there reached a record $982 million last year.

Venezuela was not far behind. It, too, has been a fast-growing market, buying about $900 million worth of U.S. farm products in fiscal 1981.

Commodity Payments: Who Benefits Most?

Farms with the most acreage get the biggest share of commodity program payments for wheat, feed grains, cotton, and rice, according to a study by USDA's Economic Research Service.

Farmers with 500 acres or more made up only 10 percent of program participants, but they received nearly half of the $2 billion in total payments. Those with less than 140 acres accounted for 50 percent of participating farmers but received only 10 percent of payments, based on 1978 commodity program participation.

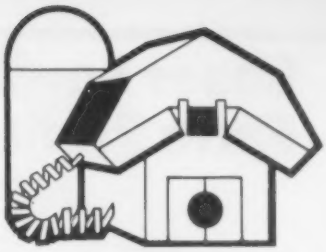
The largest farms—the 10 percent with 500 acres or more—received:

- 53 percent of wheat payments.
- 41 percent of feed grain payments.
- 66 percent of cotton payments.
- 48 percent of rice payments.

About 739,000 producers took part in the programs in 1978. They accounted for around a third of the 2.4 million U.S. farms that year. Average payment per farmer ranged from $363 for those with less than 70 acres to $36,005 for farmers with 2,500 acres or more.

Ninety-seven percent of all the program payments were for wheat and feed grains. Farmers in the Midwest—where most of these crops are grown—collected about 85 percent of the total.

The Food and Agriculture Act of 1977 placed a $40,000-a-year limit on payments per farmer. But the limitation affected very few farmers—about two-tenths of 1 percent of all participants.



According to the study, more severe restrictions on those who qualify would probably have only a slight impact on the distribution of benefits. For example, excluding "widely held corporations"—those with 16 or more shareholders—from commodity program payments would have affected only two-tenths of 1 percent of the acreage enrolled in the programs during 1978. Most corporations are family operations with fewer than 16 shareholders, and these would have still qualified for payments.

Also, most larger corporations run farms that produce commodities not covered by the programs, such as fruits, vegetables, fed cattle, and poultry.

Confinement and Animal Stress

How much truth is there to the common assumption that confinement livestock operations produce stress in animals? To find out, USDA is conducting research at the Roman L. Hruska Meat Animal Research Center in Nebraska and at several universities.

"We're looking for ways to determine whether stress exists under confinement conditions," says Terry Kinney, administrator of the Agricultural Research Service.

"Animals must receive adequate nutrition, proper housing and veterinary care, and be properly selected genetically to be productive," Kinney says.

Livestock producers have long known that unhappy animals mean lower productivity. Stress caused by boredom, fear, or frustration can lead to weight loss and reduction in growth rate.

Producers recognize tail biting among pigs and excessive pecking among poultry as symptoms of stress. Cannibalism can result if these activities aren't controlled. Loss of male sex drive, irregular female estrus cycles, and slowness in sexual maturity are other signals that animals are undergoing stress.

Stress may also be a factor in the link between confinement and animal disease.

But these risks of confinement are outweighed by its benefits, according to Roy Van Arsdall, an economist with USDA's Economic Research Service.

"Testing and experience have shown confinement methods to be the most efficient and productive way to raise livestock," says Van Arsdall. "While confinement can lead to stresses, there's also evidence that animals are more productive when they're sheltered from the elements."

Other less obvious benefits stem from confinement, according to Van Arsdall. "When animals aren't confined, their waste pollutes streams, and the paths they wear contribute to erosion."

Van Arsdall points out that animal density in a pen or cage isn't the only factor in animal stress. The number of animals kept together can affect their well-being as much as the amount of space they have.

"Animals have a social order. If that order is disrupted too seriously by grouping too many or too few animals, their productivity will be affected," he says.

"It's a matter of common sense. If producers see that productivity is dropping because of the way the animals are raised, they'll provide the conditions that will alleviate the stress. It's been proven that confinement works. What producers are doing now is fine-tuning," says Van Arsdall.

"Animal rights" groups contend that some intensive farming methods are cruel to animals, depriving them of their natural behavioral habits. Activists in Europe persuaded the Common Market to draw up rules covering the production conditions of laying hens, such as cage size. The regulations may be extended in the future to include countries exporting eggs to these nations.

The International Federation of Agricultural Producers (IFAP) says that nations where the animal rights movement is spreading, such as Australia and the United States, can draw on the experience of the European nations. It recommends more stress research of the kind USDA is doing as being in the best interests of producers, consumers, and animal rights activists alike.

IFAP also suggests that questions about animal treatment can best be answered by demonstrating that modern rearing methods are humane rather than by emphasizing the economic advantages of intensive livestock production.

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Here's the schedule for August and September:

August

2	Farm News Special
3	Poultry Slaughter
4	Agricultural Outlook
5	Farm Machinery Report
6,7,8	Farm News Special
9	Agricultural Finances
10	Livestock and Meat
11	U.S. Crop Production
12	World Supply and Demand
13,14,15	Cattle on Feed
16	Mushroom Report
17	Export Report
18	Feed Situation
19	Rice Stocks
20,21,22	Farm News Special
23	Eggs, Chickens, Turkeys
24	Farm Labor
25	Crops and Weather
26	Cotton and Wool
27,28,29	Poultry and Egg
30	Hog Report
31	Farmers' Prices

September

1	Poultry Slaughter
2	Sugar Situation
3,4,5,6	Agricultural Outlook
7	Fruit Situation
8	Crops and Weather
9	Vegetables
10,11,12	U.S. Crop Production
13	World Supply and Demand
14	Cattle on Feed
15	Tobacco Situation
16	Dairy Situation
17,18,19	Farm News Special
20	World Agriculture
21	Rice Situation
22	Hogs and Pigs
23	Eggs, Chickens, Turkeys
24,25,26	Soybean Stocks
27	Citrus Fruits
28	Potatoes
29	Agricultural Outlook
30	Farmers' Prices

All features subject to change.

Laser Leveling and Farm Profits

Laser leveling can save water and improve profits on many gravity-irrigated fields in dry western states.

Producers who look into laser leveling find that it's an expensive undertaking requiring case-by-case cost analysis. However, recent research shows that the financial benefits outweigh the costs under a wide variety of circumstances. In addition, large amounts of water can usually be conserved.

These findings are based on an Arizona study, but should also apply to several other western areas with expensive water and gravity-irrigated fields—those that depend on the natural flow of water over the field to carry moisture to the crops.

Laser leveling is used to precisely smooth these fields. It's generally employed in one of two ways: to level fields to a zero slope with borders, called basin or dead leveling; or to smooth the existing field slope by planing off all uneven spots that repel or trap water.

Both types of laser leveling improve irrigation efficiency by reducing water runoff and minimizing deep percolation beyond the root zone. Typically, only 50–65 percent of the irrigation water that's applied is actually absorbed by the crops on gravity-irrigated fields. The rest is lost to evaporation, runoff, and deep percolation.

By laser leveling to slope, the efficiency rate can be boosted to 55–75 percent. By dead leveling, 85–90 percent of the water can be expected to reach the plants.

Water Savings

The water savings can be dramatic. Take cotton, for instance. In Arizona, about 41 acre-inches of water per acre must reach the plants to meet cotton's consumptive needs. The lower the irrigation efficiency, the greater the amount of water required to achieve that level. (An acre-inch is a measure of water quantity; one acre-inch would be enough to cover an acre of land with an inch of water, or about 27,154 gallons).

The water savings on just 1,000 acres could be enough to meet the needs of a city of 81,000 for a full month.

Given a common irrigation field efficiency rate of 55 percent, some 75 acre-inches of water per acre must be applied to ensure that the cotton plants receive the required 41 acre-inches (55 percent of 75 acre-inches equals 41 acre-inches). However, if the field is laser leveled to zero slope and field efficiency improves to 85 percent, only 48 acre-inches of water must be applied (85 percent of 48 is 41).

The difference of 27 inches amounts to 36 percent or 733,158 gallons less water per acre. That's a huge savings relative to either agricultural or urban industrial demands.

In California cities, water use averages 200 to 500 gallons per person per day to meet all industrial, home, and municipal needs. Assuming an urban use rate of 300 gallons per person per day, a savings of 27 acre-inches of water per acre on just 1,000 acres would be enough to meet the needs of a city of 81,000 people for a full month.

Considering the thousands of acres where laser leveling might be economical, the water savings would be enormous. These savings would not only help stretch available water supplies but would also substantially reduce irrigation costs for many producers.

Lasering Benefits

Water can be very expensive for producers in areas where pump lifts are 300 to 600 feet, or where urban needs compete for limited surface water. Many farmers in Arizona and California face irrigation water costs of $50 or more per acre-foot, including pumping costs.

Besides savings in water and energy costs, there are other benefits for producers. Yields may increase because of more even distribution of water over gravity-irrigated fields. Agricultural engineers report that yields may improve as much as 30 percent in some cases, although data is lacking on the exact conditions under which yield gains can be expected.

Additional financial incentives for laser leveling include federal tax and cost-share benefits. Farmers may deduct water conservation investments from taxable income, up to a maximum deduction of 25 percent of gross farm income per year. Since many farmers who irrigate are in the 35–50 percent tax bracket, this tax incentive is an important consideration.

The cost-share program offered by USDA's Agricultural Stabilization and Conservation Service (ASCS) varies among regions. The ASCS payment is typically around half of the water conservation investment, up to a maximum of $3,500 per year.

Lasering Costs

Despite the incentives, the costs of laser leveling can be formidable. Costs often amount to 25 percent of the value of the irrigated farmland.

In Arizona, investment costs range from $100 to $200 per acre for laser leveling to slope, and from $400 to $600 per acre for dead leveling. More than half the investment usually pays for major earth moving—a necessary step before laser equipment can be used to accurately smooth the field.

Other costs include removing and relocating old ditch systems, installing erosion control structures and check gates, and, in some cases, chiseling to loosen subsoil and applying manure to replace topsoil.

The loss of revenues while fields are being laser leveled is an indirect cost that shouldn't be ignored. There may also be continuing costs associated with

Illustration by Mark Lynham.

Promising New Technology

Laser leveling is a promising new technology first used in agriculture in the mid-1970's.

Laser leveling has probably been used more in Arizona than in any other state, and it's gaining ground each year. So far, however, less than 10 percent of the state's gravity-irrigated acreage has been laser leveled, according to most estimates. In laser leveling, a field is first graded by regular earth-moving equipment to flatten out hills and depressions. Then the laser technology moves in to precisely level or smooth the field.

A laser beam set to dead level or a specific grade is transmitted by a rotating command post placed on or near the field. The beam is picked up by a receiver that's attached to a tractor-mounted scraper. The receiver automatically operates hydraulic control valves that raise and lower the tractor's scraper blade, keeping it at the desired grade.

Past grading technology relied on the judgment of the scraper operator to even out high and low spots designated by marked stakes. In contrast, the laser beam and its receiver precisely control the depth of the scraper blade. Other automatic leveling processes haven't been developed for farmland that can do the job as efficiently, reliably, and economically as the extremely accurate laser.

As laser leveling becomes more common, it is also likely to become less expensive. In addition, as water and energy prices rise, the technology will become profitable for more fields, and more farmers are expected to turn to laser leveling.

added tractor turning time because fields are often subdivided in the leveling process to spread water more quickly and evenly. Other extra costs may result from more frequent switching of water from basin to basin, and possibly from more acreage in roads and canals.

Operation and maintenance costs are relatively small—perhaps $50 per acre every 5 years to touch up depressions and hills.

When It's Profitable

Although a producer should make a detailed cost analysis before deciding to laser level a field, break-even water costs can be estimated to indicate the conditions under which lasering might be worthwhile.

The purpose of break-even calculations is to show when the cost to pump (or divert) and deliver water to the field reaches the point at which an investment in laser leveling would be profitable for the individual farmer. If the actual cost of water to the producer is higher than the break-even cost, the investment is profitable. If lower, the investment is not profitable.

Break-even estimates must take into account real (inflation-adjusted) prices of energy for pumping and alternate planning horizons (the expected lifespan of the investment). A long planning horizon (say, 50 years) may be appropriate for some farmers since, with periodic touchup, the laser investment should have an infinite life.

On the other hand, some farmers may expect their land to be purchased for urban development, or that lasered fields will be made obsolete by some future technology. In that case, a shorter planning horizon (perhaps 25 or even 10 years) might be more appropriate.

The accompanying diagram shows break-even water costs under a wide range of plausible assumptions. Break-even costs for dead leveling are higher than for slope leveling because of the much higher initial investment per acre.

For both types of laser leveling, the greater the water savings and the longer the planning horizon, the lower the break-even cost. Likewise, any increases in real water pumping costs or any gains in yields made possible by laser leveling reduce the break-even cost.

The greater the water savings and the longer the planning horizon, the lower the break-even cost.

Take, for example, a farmer whose investment costs for lasering to dead level would be $400 per acre, whose water savings would be 20 acre-inches per acre, and whose planning horizon would be 25 years. Assume also the other conditions listed in the footnotes to the diagram.

If no increases in pumping costs were anticipated and no yield change could be expected from laser leveling, the break-even water cost would be $60 per acre-foot. If the farmer now pays more than $60 per acre-foot to purchase or pump and deliver the irrigation water, the lasering investment would be profitable. If less than $60, it would not.

However, if real pumping costs for water were rising 3 percent, the break-even cost of laser leveling would drop to $44—near the actual cost of water faced by many farmers. Even more significant would be the effects of a yield change due to laser leveling. If yields could be expected to increase 10 percent, the break-even cost of laser leveling would drop to only $17 (even without any change in real pumping costs).

A related financial consideration is the rate of lasering, or how many acres to laser a year. Since federal tax incentives and ASCS cost-share programs have annual dollar limits, farmers can often increase benefits by lasering over several years. On the other hand, farmers must weigh any gains in government benefits against forgone water savings and yield gains.

The most profitable period for completing laser leveling depends partly on the gap between the break-even cost and the actual cost of water. In general, the smaller the difference, the greater the advantage of spreading laser leveling out over a number of years. □

[Written by agricultural economist Harry Ayer of the Natural Resource Economics Division of USDA's Economic Research Service. Further information on the costs and benefits of laser leveling can be found in the report, ***Laser Leveling and Farm Profits,*** *by John Daubert and Ayer. For a copy, write to Harry Ayer, ERS, USDA, Department of Agricultural Economics, University of Arizona, Tucson, Arizona 85721.]*

Many Farmers May Find their Actual Water Costs Are Higher Than the Break-Even Costs of Laser Leveling

	Lasering to Slope ($200 per acre investment cost)[3]				Lasering to Dead Level ($400 per acre investment cost)[3]			
Acre-inches of water saved per acre	10 acre-inches		15 acre-inches		20 acre-inches		30 acre-inches	
Planning horizon[1]	10 years	25 years	10 years	25 years	10 years	25 years	10 years	25 years
Break-even costs, assuming no yield change and:	(break-even costs: dollars per acre-foot)							
No change in pumping costs	$58	$39	$40	$27	$84	$60	$56	$40
3% increase in pumping costs	$52	$30	$35	$20	$75	$44	$50	$30
Break-even costs, assuming yield increase[2] and:								
No change in pumping costs	$31	$13	$21	$9	$43	$17	$28	$12
3% increase in pumping costs	$27	$9	$19	$7	$37	$13	$25	$8

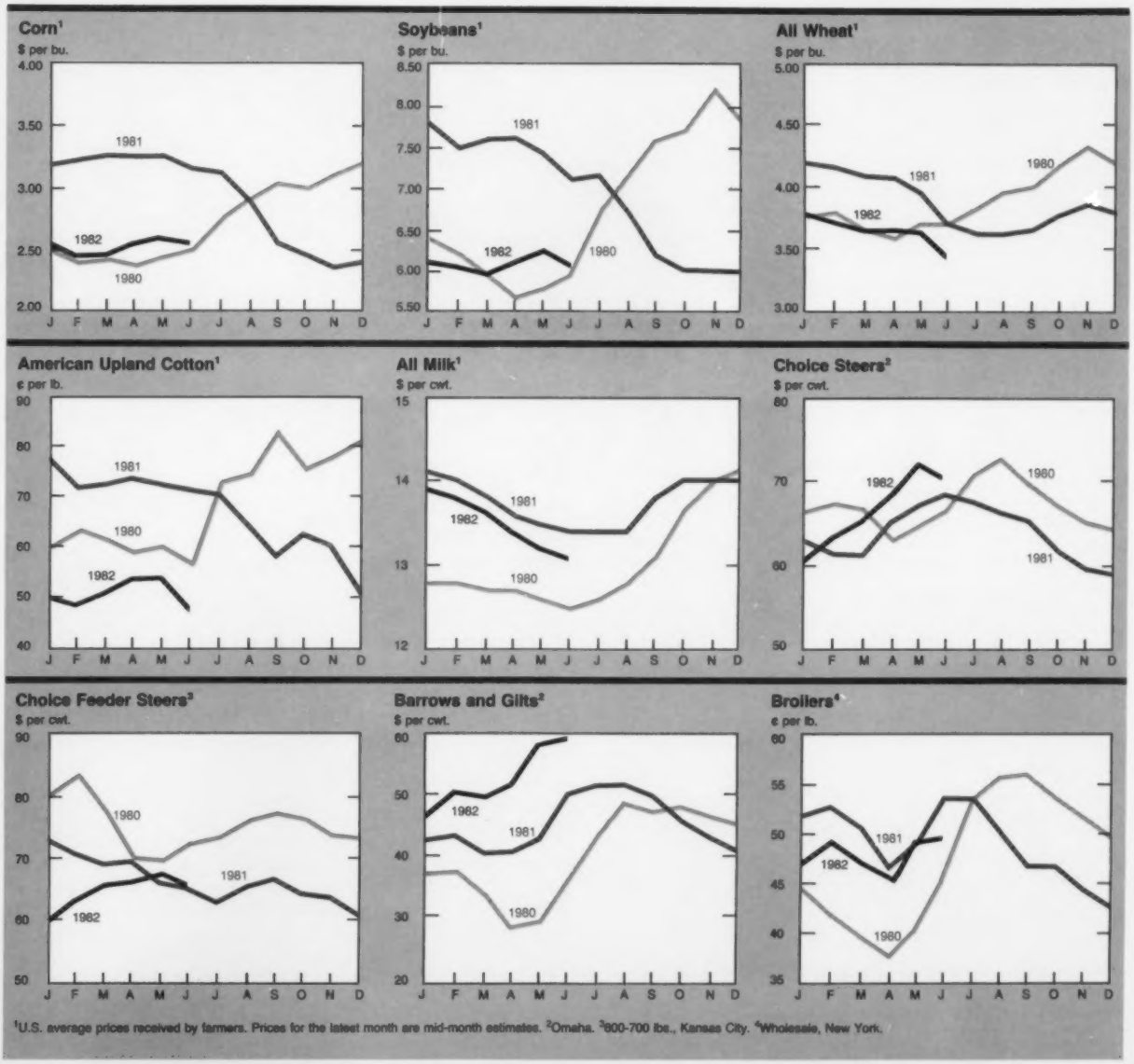
[1]The planning horizon refers to the expected lifespan of the investment. [2]Figures are based on a 3% increase in yield for lasering to slope and a 10% increase in yield for lasering to dead level. [3]Cost will vary.

Additional assumptions include: farm size of 500 acres; gross farm income of $700 per acre; a marginal tax rate of 35%; a real rate of discount of 5%; net revenue crop loss while lasering of $150 per acre; operation and maintenance costs of $50 every 5 years; machine, labor, and lost acreage costs on dead level fields of $37 per acre; and that the entire farm is lasered in 1 year, so that only 1-year's ASCS cost share and federal tax advantages are available.

FARMLINE TRENDS

Monthly Price Monitor

After rising 2 months in a row, USDA's overall index of farm prices dropped a percent from May to mid-June. The downturn affected all commodities charted here, except barrows and gilts and broilers. Wheat prices slumped to their lowest level since spring 1979, cotton to its lowest since summer 1975, and milk to its lowest since fall 1980. Livestock prices remained fairly strong, although Choice steer and feeder steer prices slipped from their May peaks. All June crop prices were well below year-earlier levels, but steer, feeder steer, and barrow and gilt prices were higher.



[1]U.S. average prices received by farmers. Prices for the latest month are mid-month estimates. [2]Omaha. [3]600-700 lbs., Kansas City. [4]Wholesale, New York.

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